Advanced Gas Sensing Technologies

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# Report Documentation Page

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| **unclassified** | **unclassified** | **unclassified** | **Same as Report (SAR)** | **36** | |

# New Continuous Monitoring Technologies for Vapor Intrusion, Remediation and Site Assessment.

## Benefits of Time series Data

**Dr Peter Morris, Geoff Hewitt**

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Why do we monitor Ground-Gas/Vapours?

Health and Safety – range of toxic affects explosion, suffocation

Contaminated land site investigation and remediation design – cost implications

More recently green house gas agenda - Carbon auditing

Ozone depletion

# Objectives of ground gas/vapour monitoring

- Determine the true subsurface vapour/gas regime
- Predict how this may change in the future

Currently achieved by:

Discrete periodic static measurements of vapour/gas concentrations and the vapour/gas regime is inferred

# Flawed approach

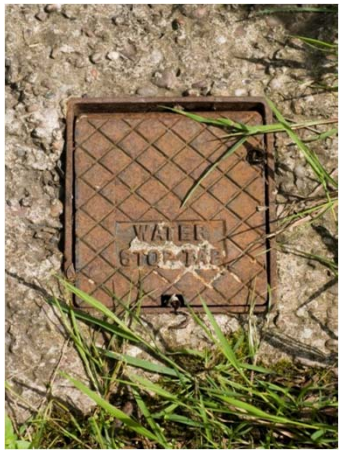
- Many environmental parameters show high temporal variability, therefore, their representative measurement requires multiple measurement.
- In the case of vapour/ground-gas risk assessment flaws in the existing multiple measurement approach have been identified explicitly in the literature in the UK (Wilson & Card, 1999) and are subject to continuing correction (e.g. CIEH).

- The two underlying causes of these flaws are that, whilst accurate quantification of risk requires accurate measurement of vapours,

1. They are not measured directly:
- concentration of vapour/gas in the ground is inferred from periodic (weekly – monthly) sampling of vapour/gas accumulated within a borehole (or soil sample)

- The relationships these inferences are based on will be highly site-specific.

2. Likely to be temporally variable.



Safe and secure

GasClam - Key features

- Continuous monitoring of VOC,$CH_4$, $CO_2$, $O_2$, $H_2S$, CO barometric & borehole pressure and water level
- CSA C US approved (Class I, Zone I, Ex d ib IIB T4/ Class I, Zone I, AEx d ib IIB, T4)
- Extended deployment, up to 1 months based on hourly sampling
- Robust stainless steel design
- Fits directly in 50mm borehole (easy to adapt)
- Venting and vented modes
- Easy to use and deploy

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# Easily installed, easily relocated

0:00 mins

**Arrive**

**Install**

1:30 mins/s

**Go!**

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# Variable VOC concentrations?

| | WS1 June 09 | WS1 July 09 |
|---|---|---|
| **Compound** | **ug/m³** | **ug/m³** |
| Methylcyclohexane | <0.6 | 150 |
| Methylisobutylketone | <0.5 | <0.4 |
| Dimethyldisulfide | <1 | <0.8 |
| Toluene | 25 | 370 |
| Butyric Acid | <4 | <3 |
| n-Octane | 37 | 580 |
| Ethyl Butyrate | <0.9 | <0.8 |
| Butyl Acetate | <0.8 | <0.7 |
| Tetrachloroethene | <0.3 | <0.3 |
| EthylCyclohexane | <0.4 | 190 |
| Chlorobenzene | 29 | 550 |
| EthylBenzene | 640 | 1900 |
| m-Xylene + p-Xylene | 33 | 840 |
| n-Nonane | 17 | 780 |
| Styrene | <0.4 | 150 |

Variability of VOC's as detected by 'spot' sampling – suma canister Brownfield site NW UK

Confusing data, problem with sampling?

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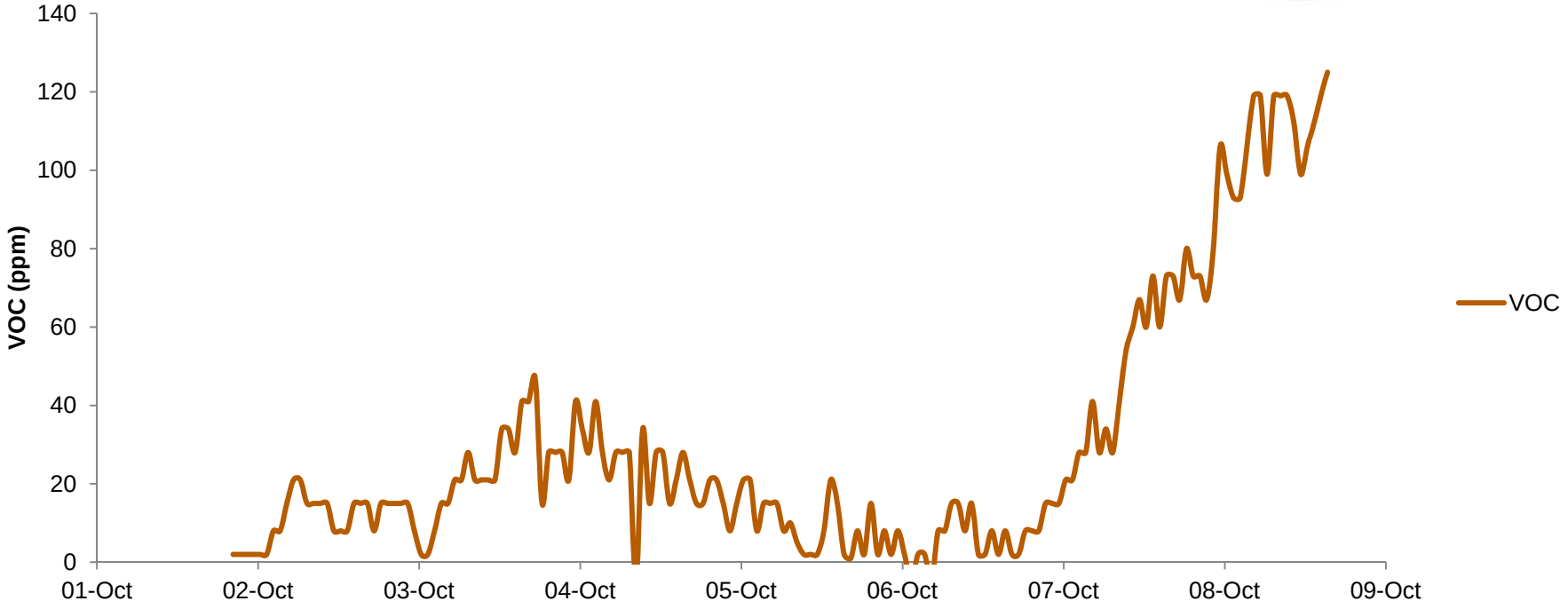
# Variable VOC concentrations?




Continuous VOC data indicates concentrations are variable

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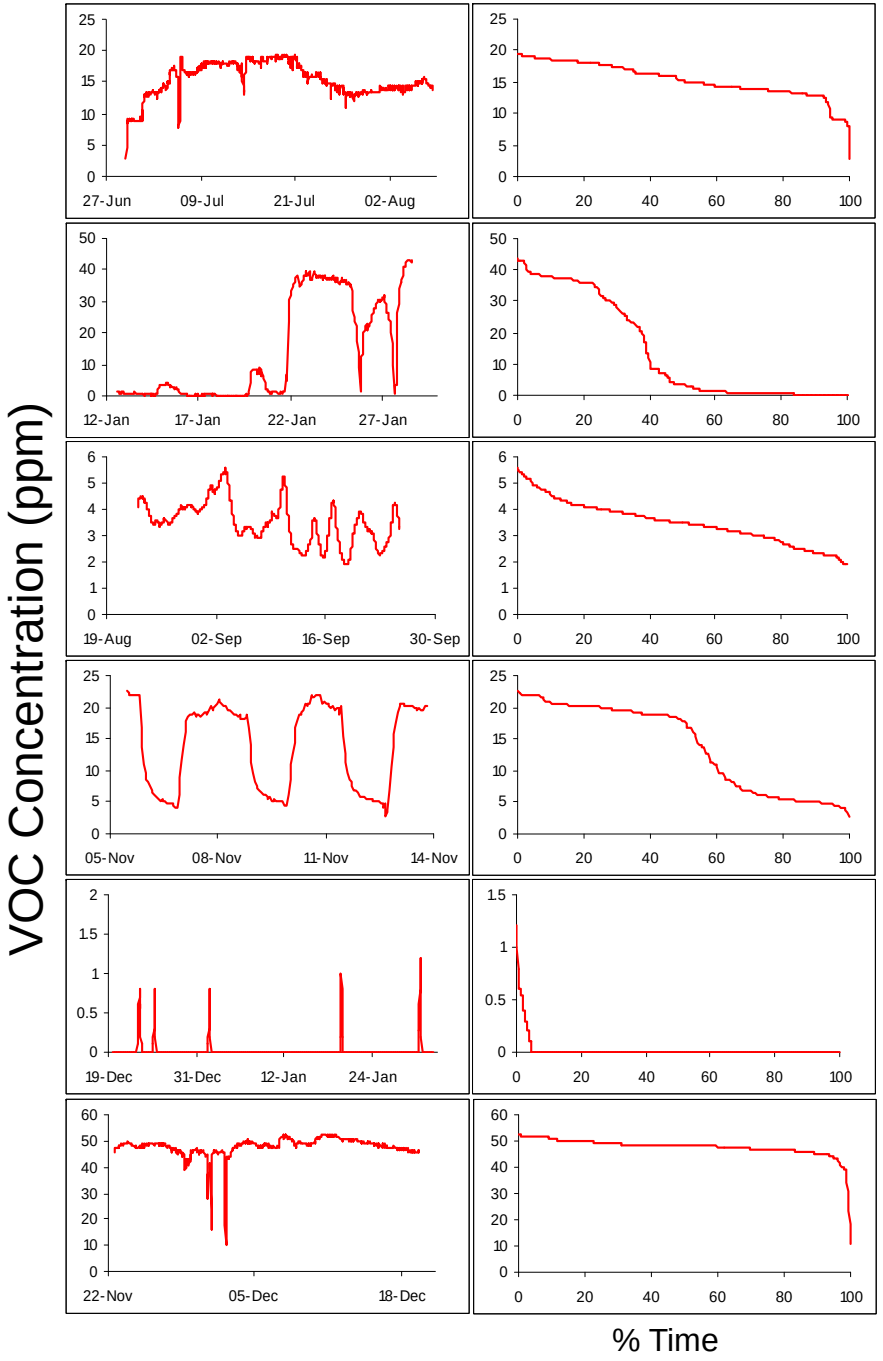
# Detection

- Demonstrates the variability of concentrations from different sites
- The possibility of relevant risk prediction
- However, reduction in interpolation errors but potential for extrapolation error remains



# Prediction

- Worst case must be predicted rather than detected
- Understanding of generic processes must be improved in order to increase confidence in prediction

# Continuous monitoring improves prediction

because of the increased certainty in recognising and quantifying relationships between gas concentration and other environmental parameters because:

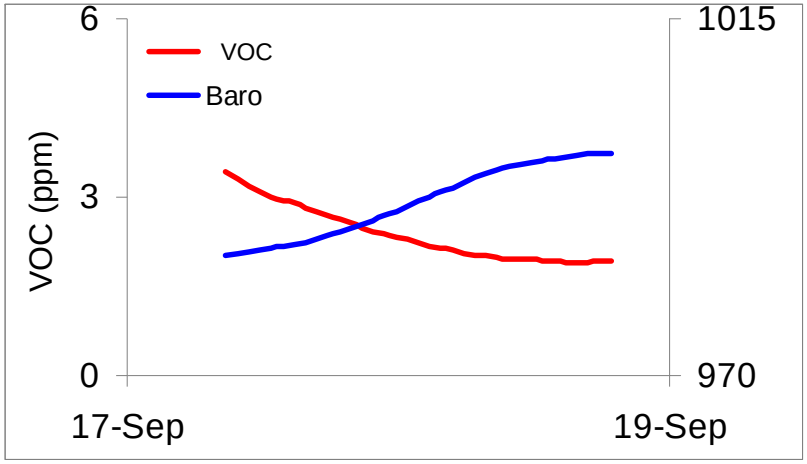
1. many more pairs of gas concentration and environmental data points are available to correlate,
2. sampling frequency matches the variability of the parameters measured so data can reasonably be regarded as a time series and the influence of conditions in altering relationships can be recognised,

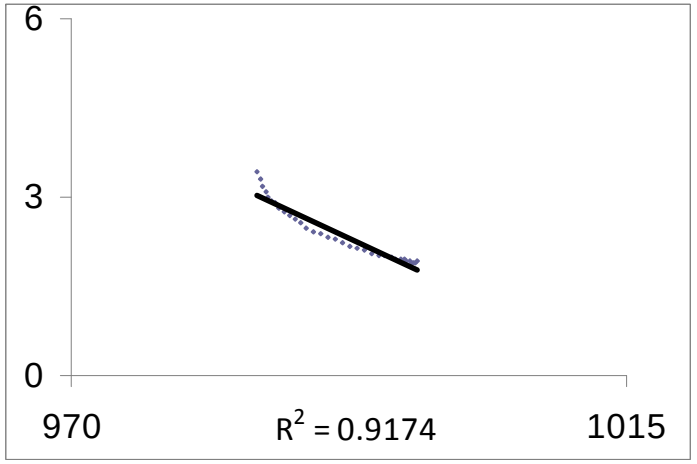
# Processes controlling intrusion/migration

The principal controls on gas migration are:

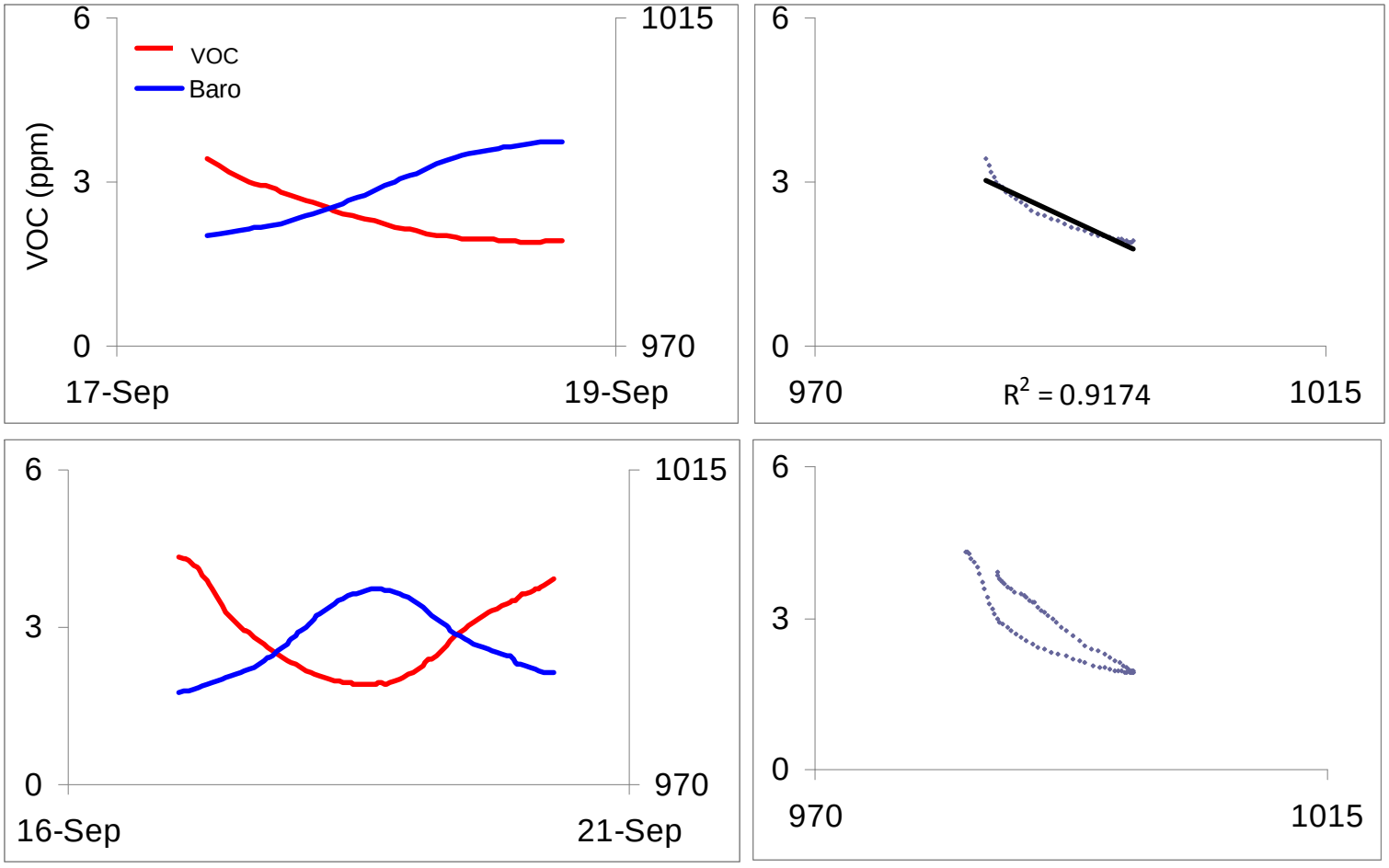
- Differences in fluid pressure – **atmospheric pressure** and water table changes
- Change in temperature
- ground permeability – vegetation, meteorology, development

# Observing concentration and atmospheric pressure

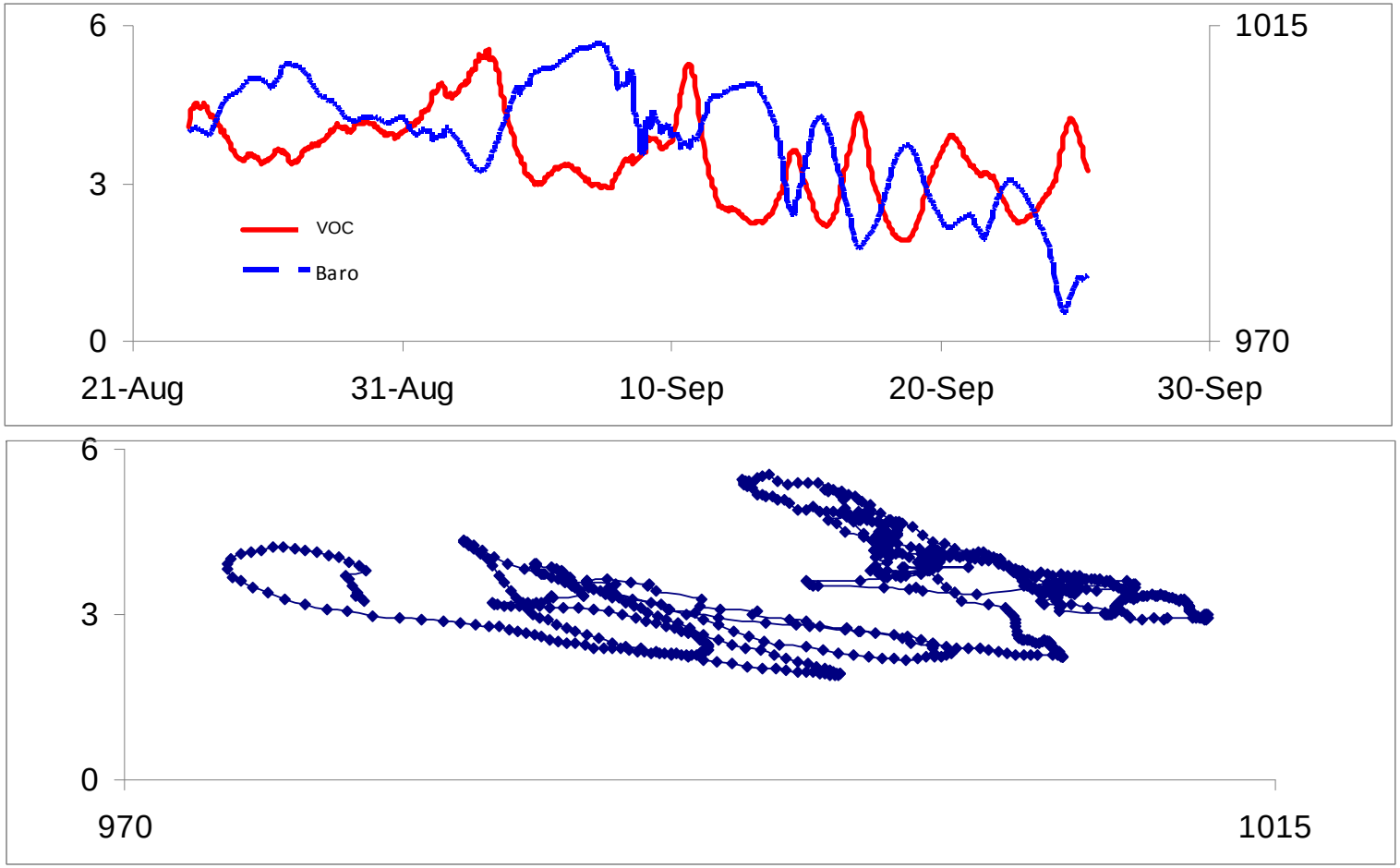


# Observing concentration and atmospheric pressure



# Longer monitoring period



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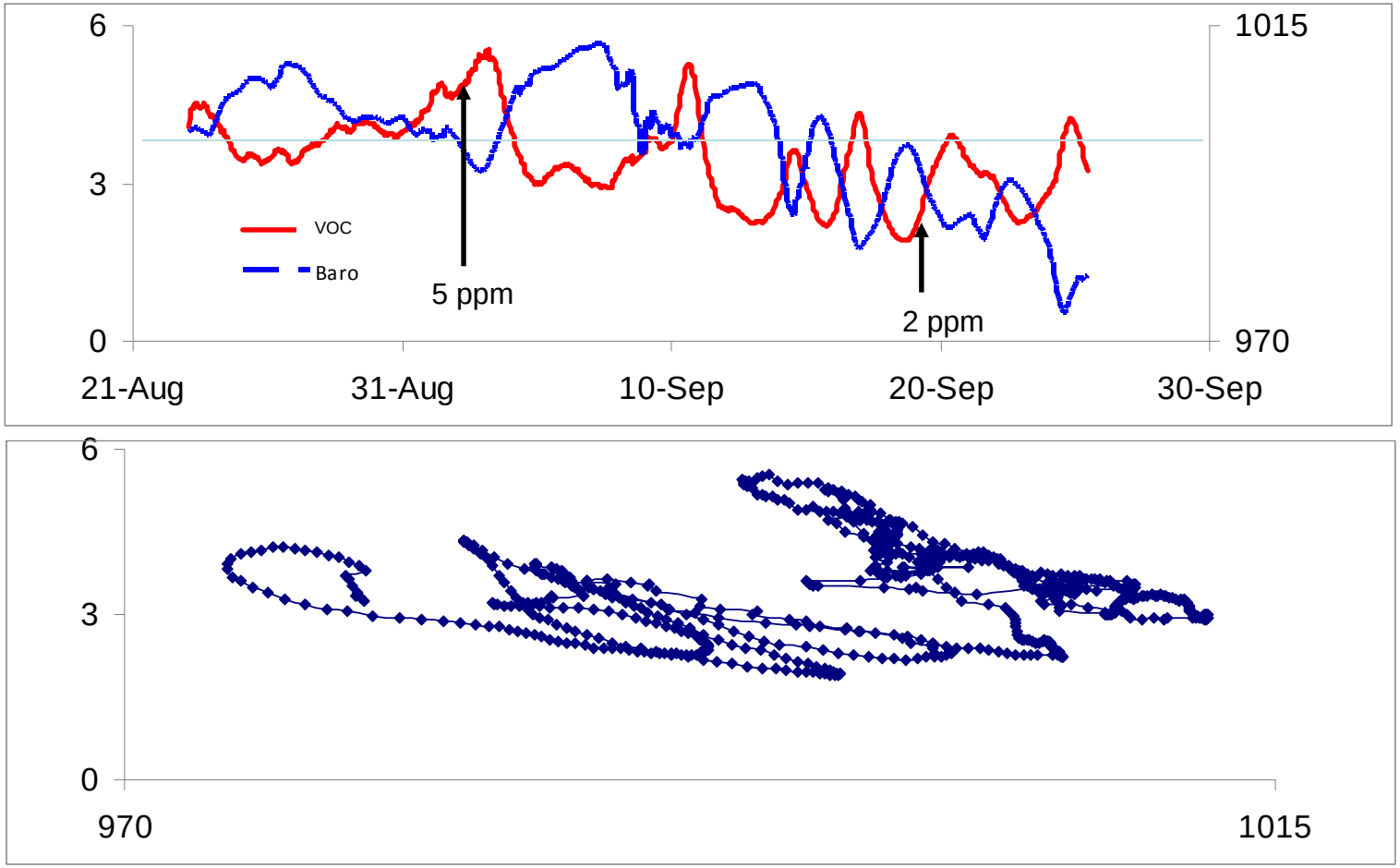
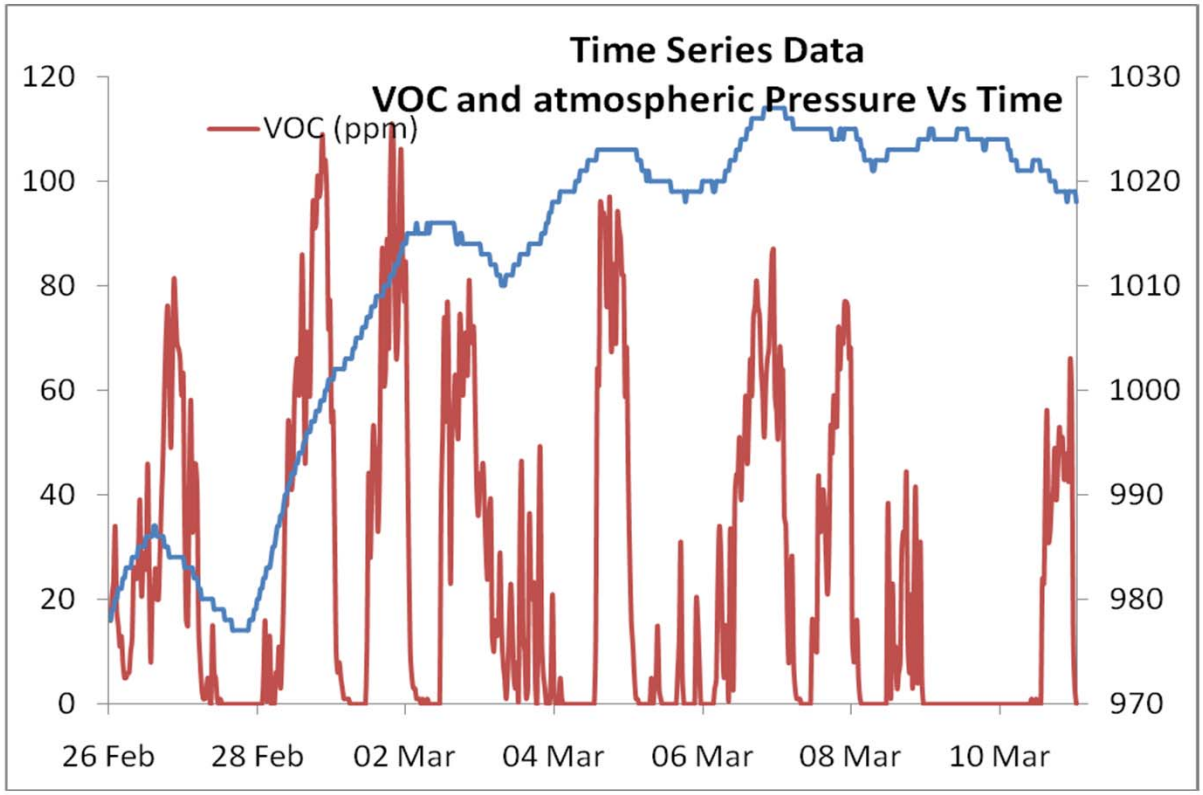


Periods with the inverse relationship with pressure




House adjacent to petrol station – Owner complaining of VOC smell
Local Authority sent in-door air quality team but nothing detected!

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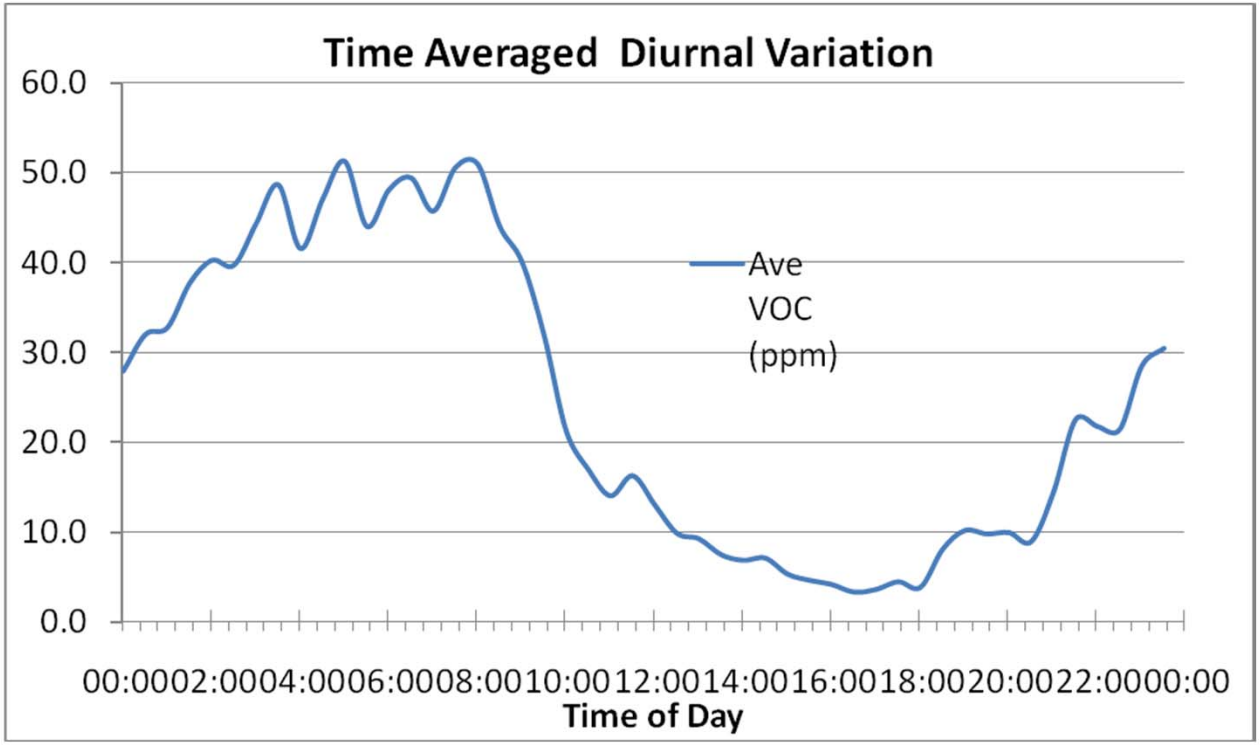


Highest concentrations at night – low in day time

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# Observing Temperature and Concentration

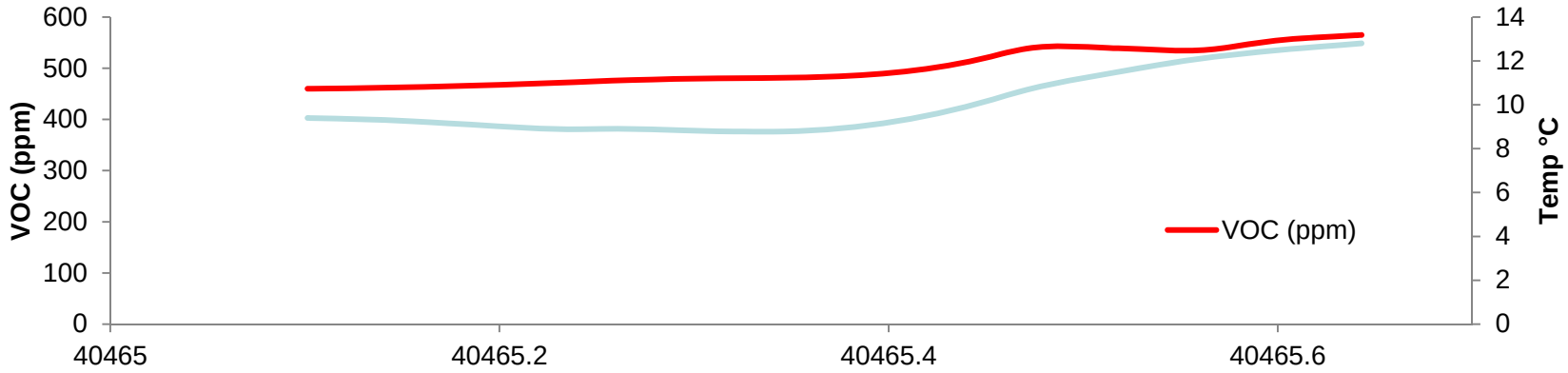
Bangor Gardens, Maine

1960’s Military Housing with underground storage tanks

UST were supposed to be removed and replaces with above ground storage tank

However 2010 VOC leak reported.

# Observing Temperature and Concentration




High VOC concentrations Prior to SVE

Increase concentration with temp

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# Observing Temperature and Concentration

Bangor Gardens, Maine – Military Housing
UST leaking

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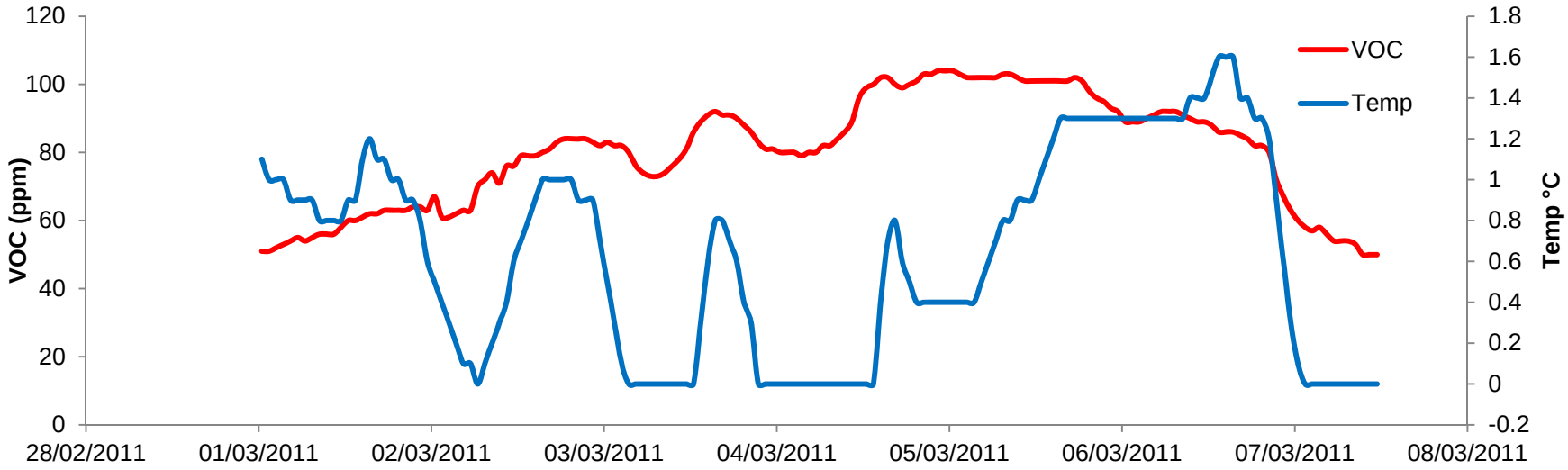


Concentration much lower following SVE but clear dependency on temperature

1°C change results in 35 ppm!

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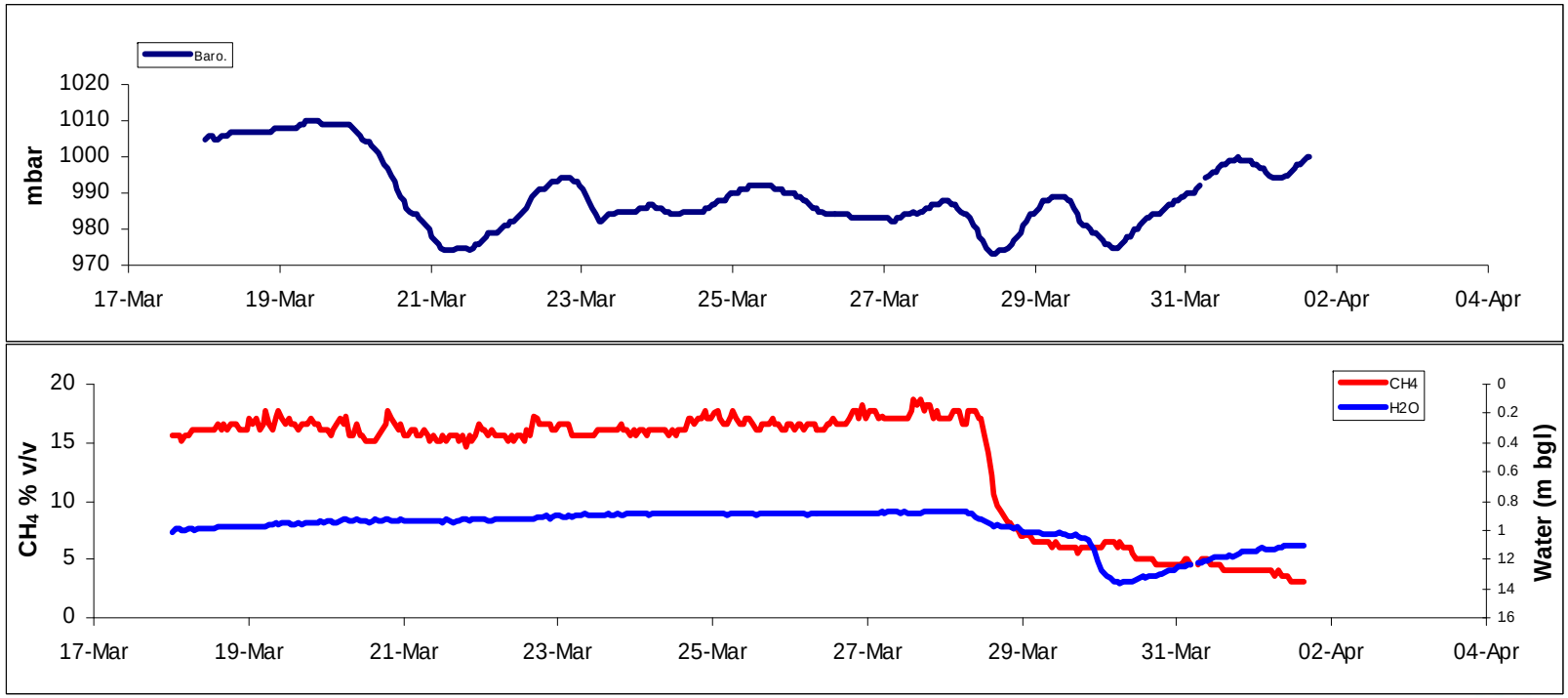
Sometimes other environmental parameters are responsible for change in gas/vapour regime

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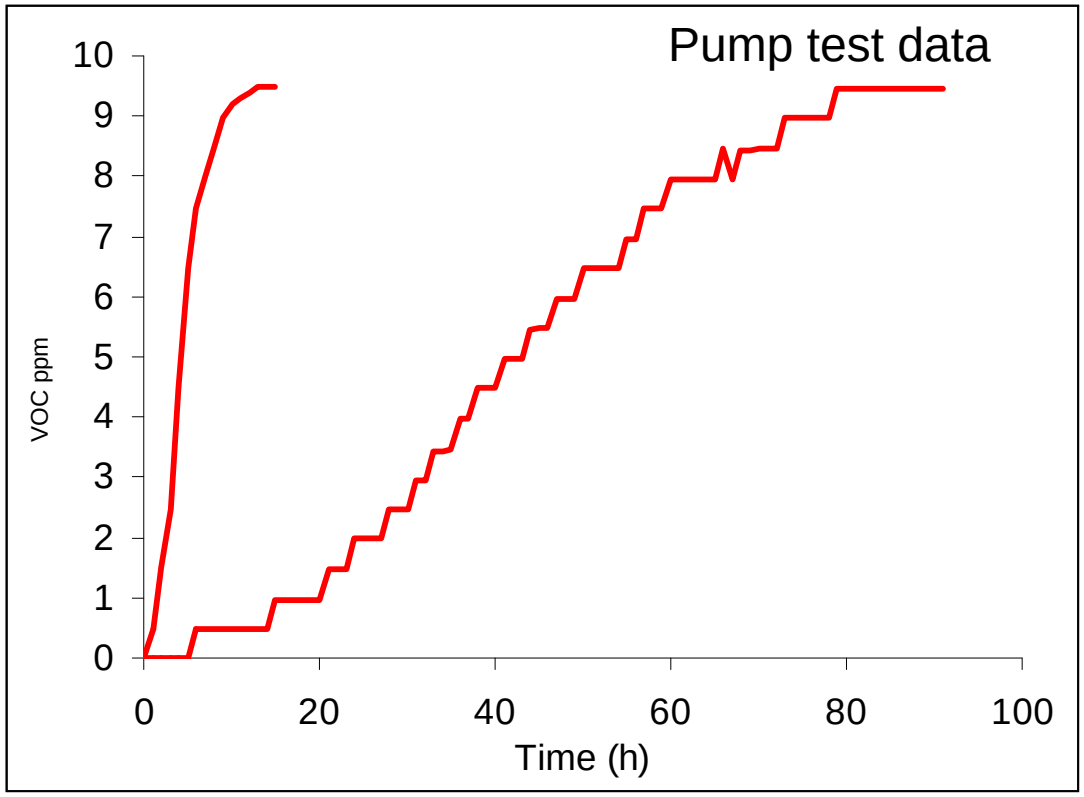
# Characterising the borehole

What does the concentration I measure tell me?




Concentration recovers after a pump test can be very different. The absolute concentration in both cases is the same, but which poses a greater risk?

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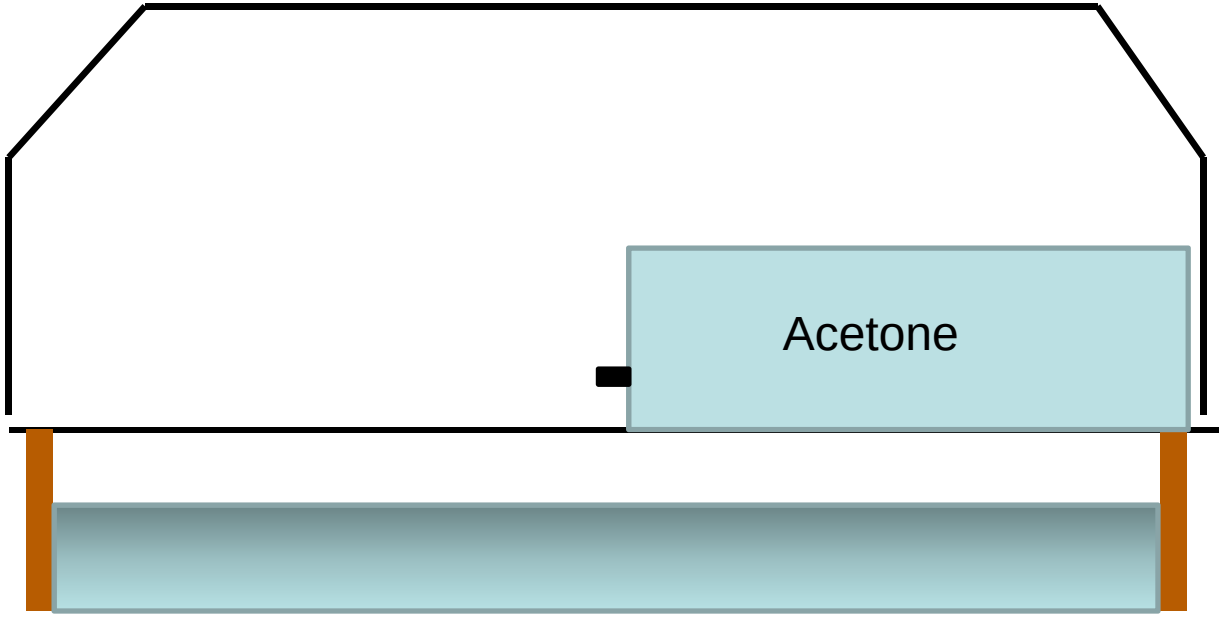
Site characterisation and Real time monitoring of Remediation




Industrial facility with VOC Leak

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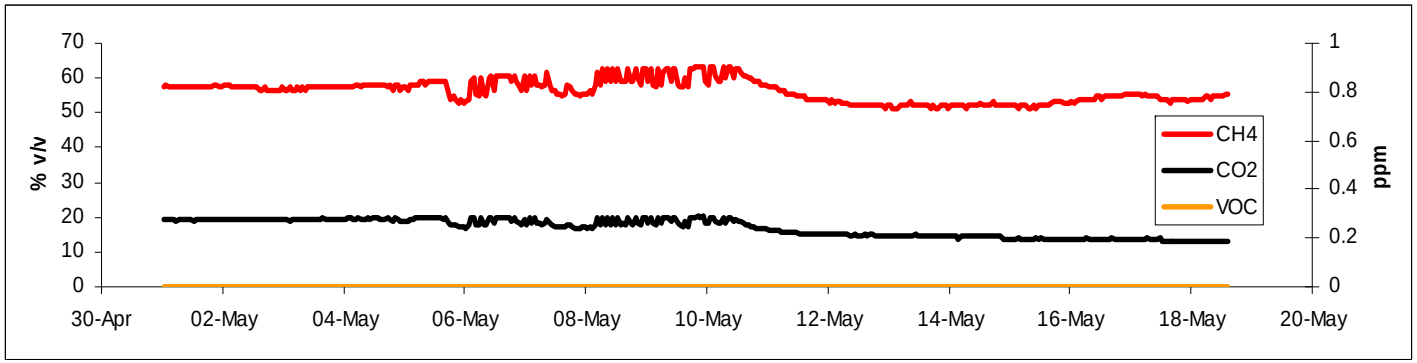
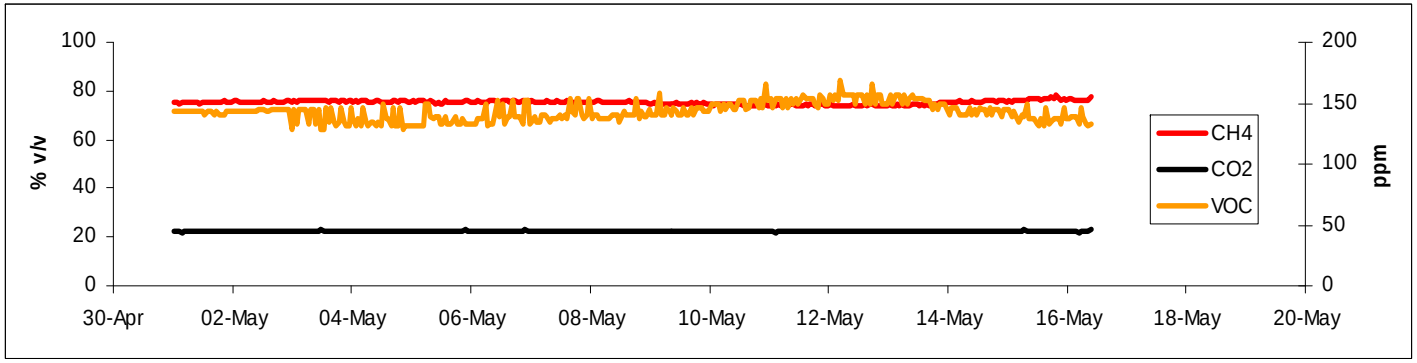
# Site characterisation




Outside Building




Inside foundations

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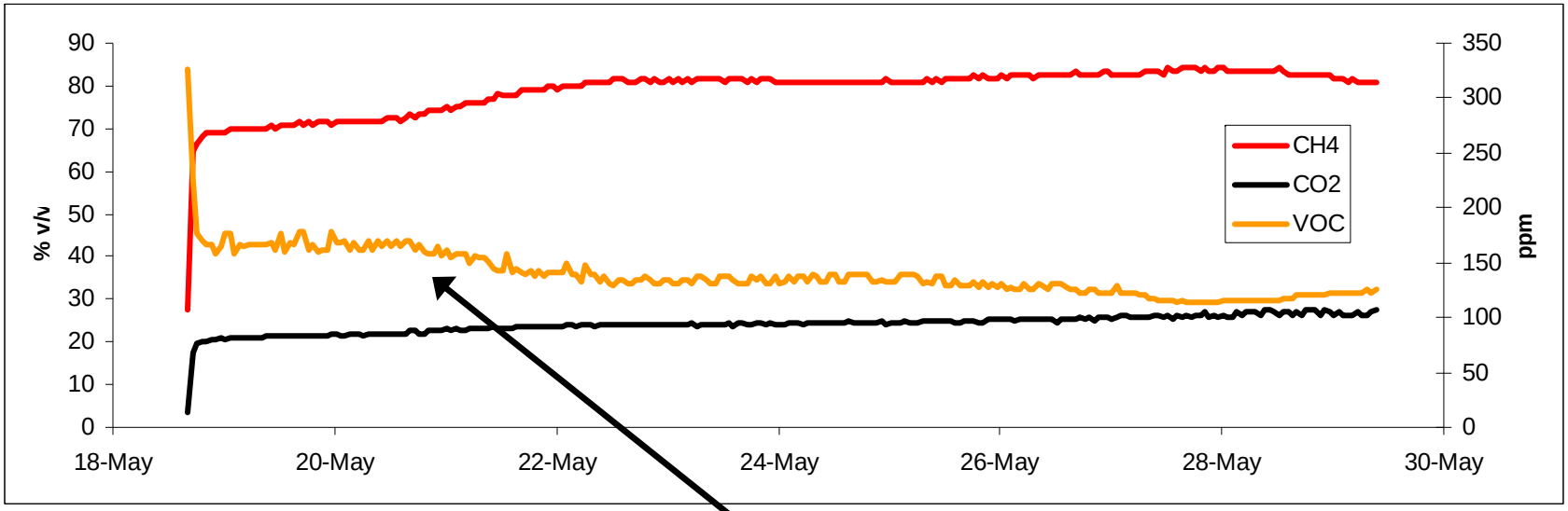
# Real time monitoring of Remediation




Dual Phase Extraction

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# Respirometry

to detect and quantify soil contamination
e.g. suppression of aerobic respiration

- Sensitive
- Responds only to bioavailable toxins

BUT

- Only ex-situ;
- findings less representative

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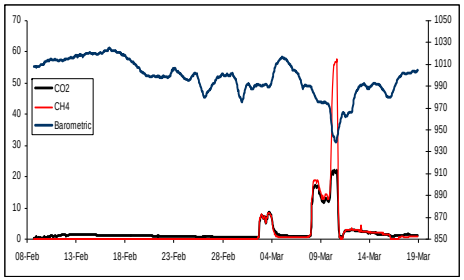
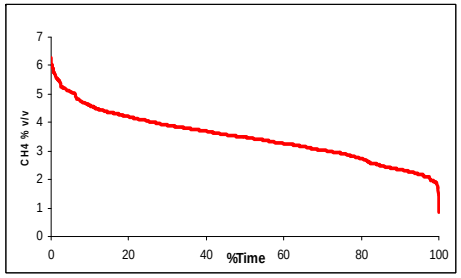
# In-situ respirometry

- Gasclam is ideal for in-situ respirometry
- Monitoring health of soil (active aerobic respiration)
- Monitoring contaminant impacts (suppression of respiration)
- Monitoring breakdown of organic contaminants by soil microbiota

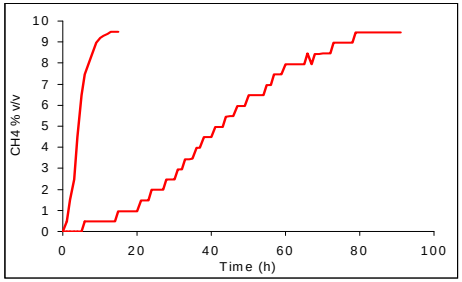
# For same resource and effort




Correlations




Concentration duration




Pump Test

Or?

| Visit | VOC (ppm) | mBar | Temp °C |
|---|---|---|---|
| 1 | 2 | 1010 | 15 |
| 2 | 10 | 1005 | 13 |

You decide!

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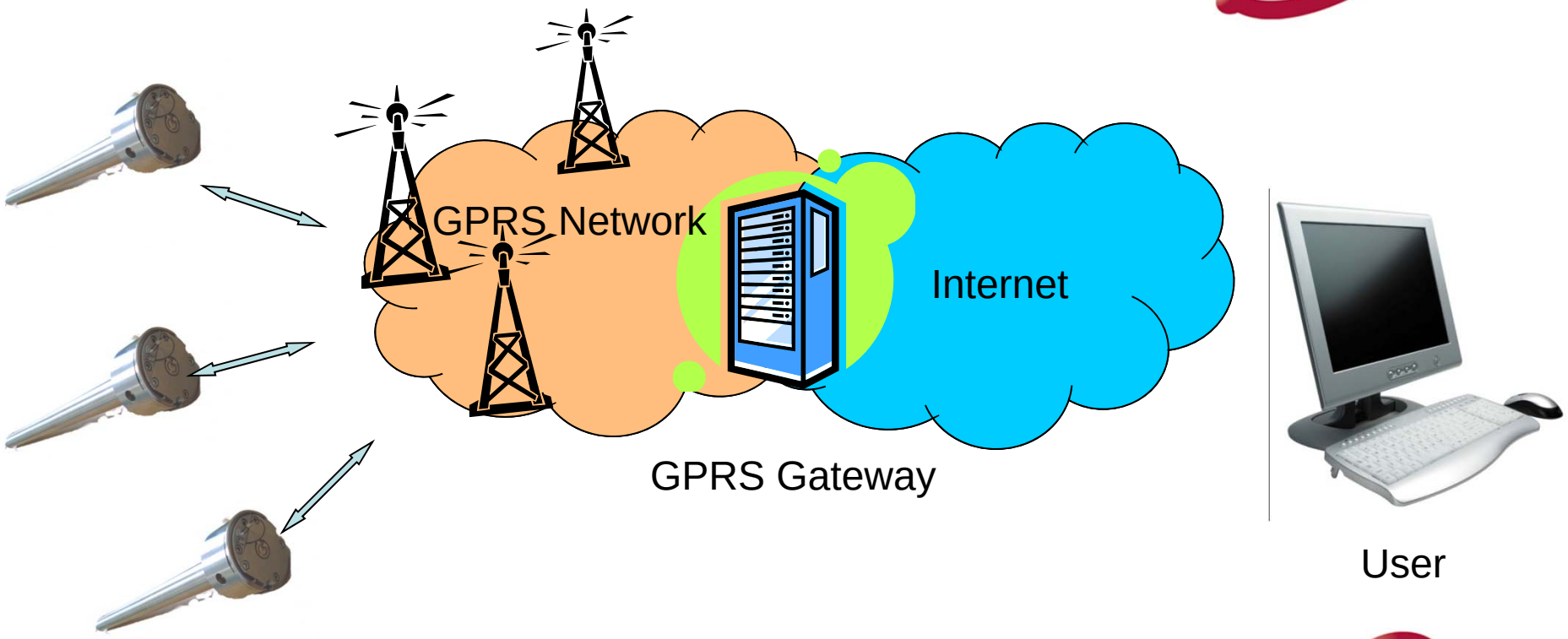
# Telemetry

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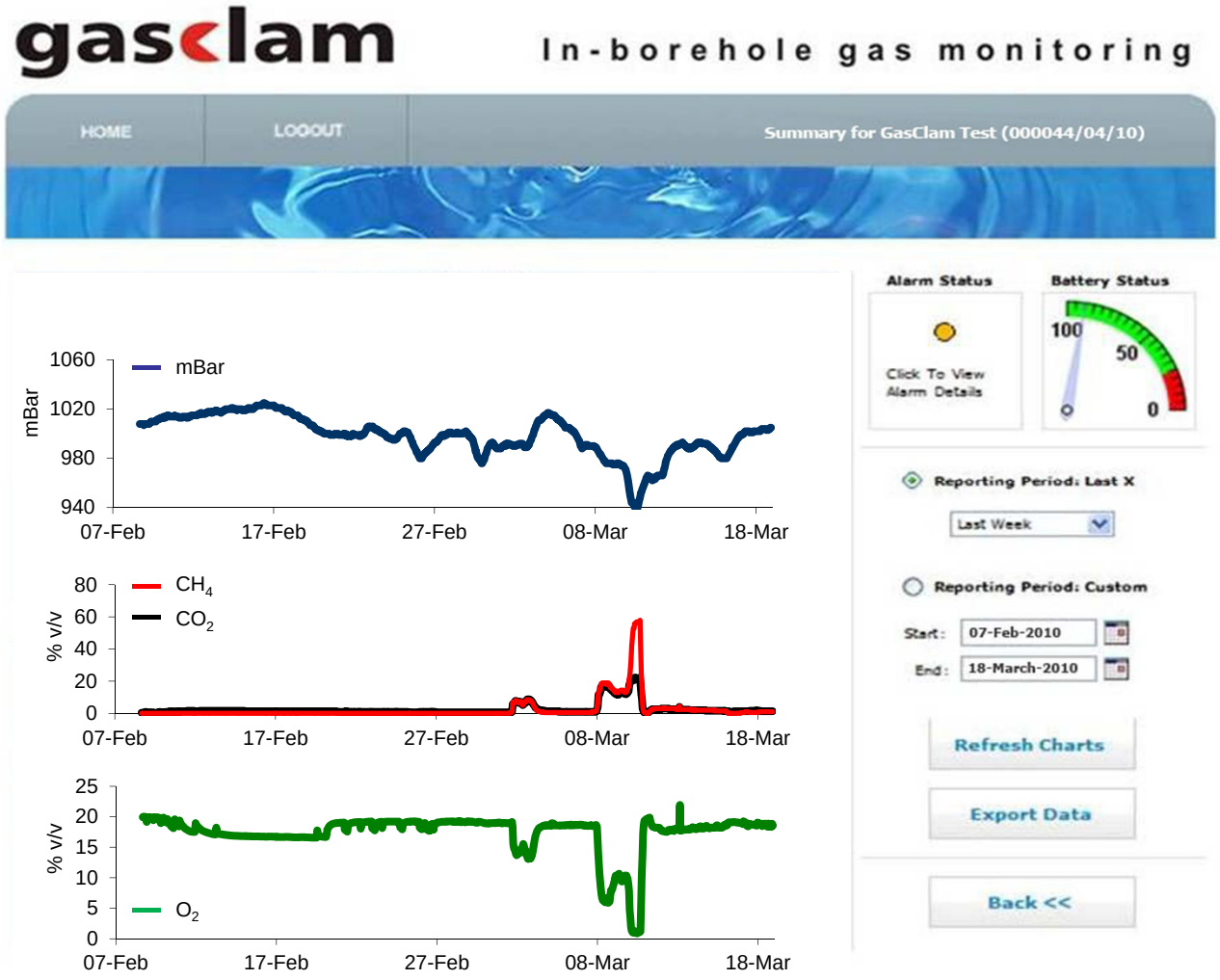
# Reporting

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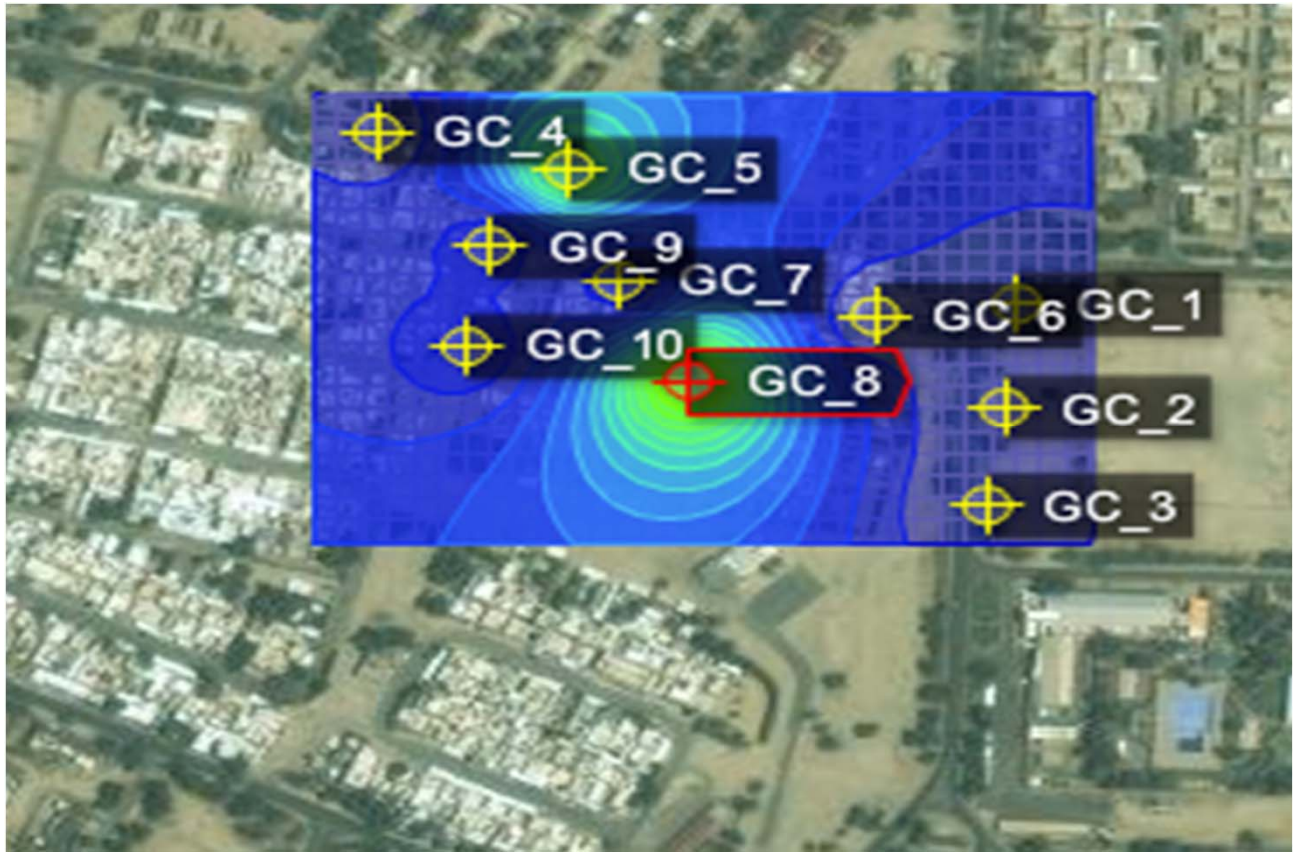
# Area Monitoring

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# Hierarchy of Cost-Benefits

**Unmanned data Collection**

Efficiency savings in meeting existing legislative requirements.

**Reduced uncertainty about vapour regime (improved conceptual model)**

Optimisation of design of remediation/vapour protection measures

Optimisation of operations for biogas production/greenhouse-gas emissions.

**Pre and Post development condition monitoring with telemetry**

Demonstration of low risk by monitoring rather than as a consequence of remedial engineering.